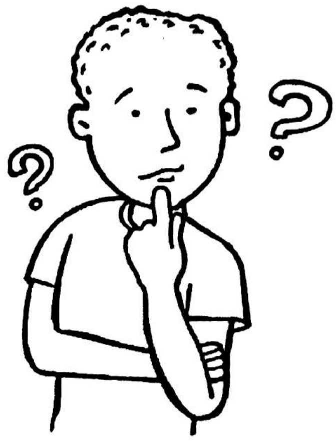
Electronics_1

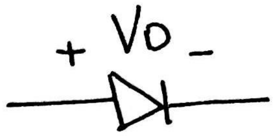


Final Revision

Part (3)

Diode Circuits

[1] Large signal model:



(i) Ideal model:

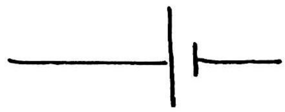
$V_D > 0 \xrightarrow[\text{diode with}]{\text{replace}}$ Short Circuit

$V_D < 0 \xrightarrow[\text{diode with}]{\text{replace}}$

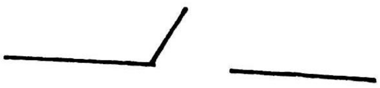
open circuit

(ii) Constant Voltage model

$V_D > V_{D,on} \xrightarrow[\text{diode with}]{\text{replace}}$



$V_D < V_{D,on} \xrightarrow[\text{diode with}]{\text{replace}}$



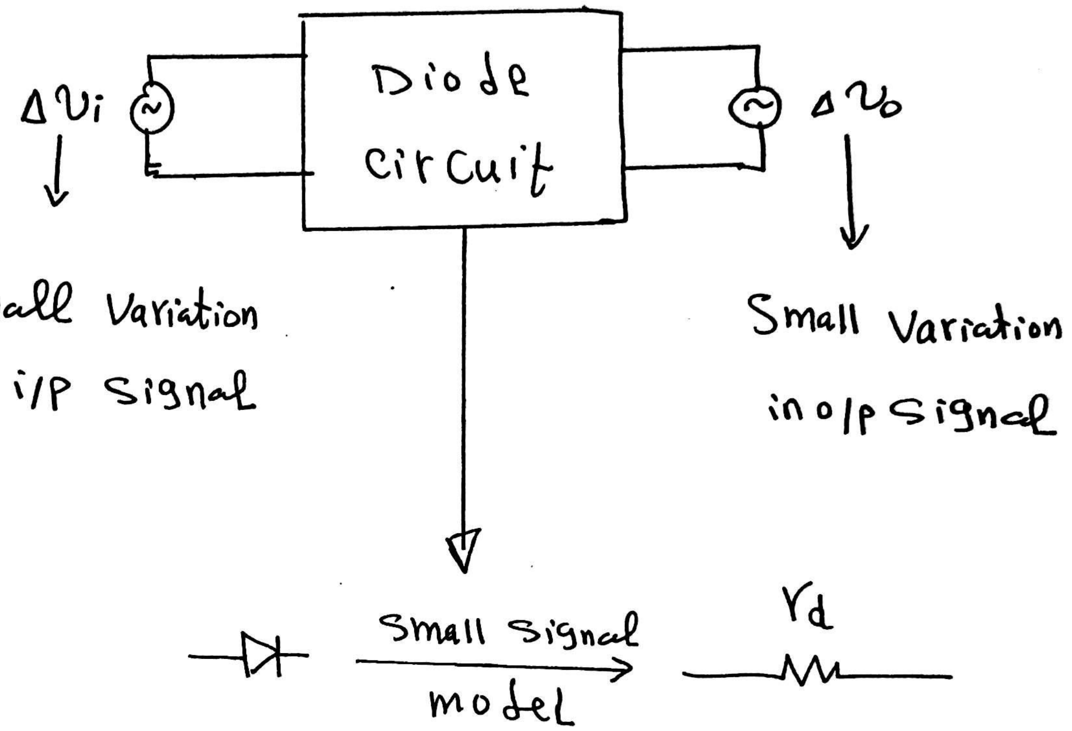
open Circuit

(iii) Exact model:

$$I_D \simeq I_S \, e^{\frac{V_D}{V_T}} \quad , \quad V_D = V_T \ln\left(\frac{I_D}{I_S}\right)$$

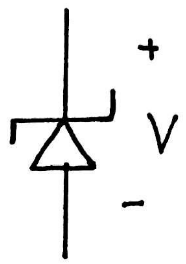
* مُهِم جداً ! (زاكر صفحة 12)

[2] Small signal analysis

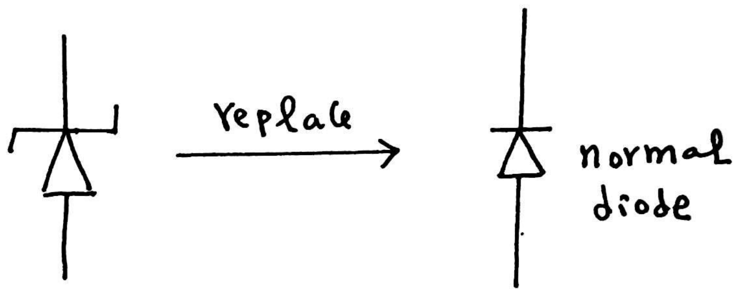


Where $r_d = \dfrac{V_T}{I_D}$

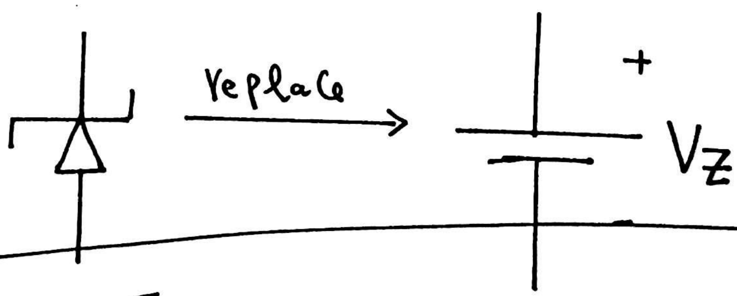
Zener diode :



If $V < V_Z$



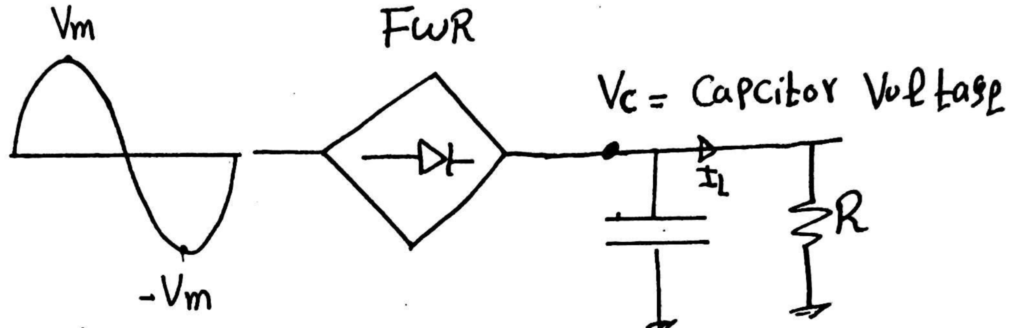
If $V > V_Z$



هام : زا آخر ملزمة (13) بالملاحق

Diode Applications

* How to Convert Ac signal to DC signal:



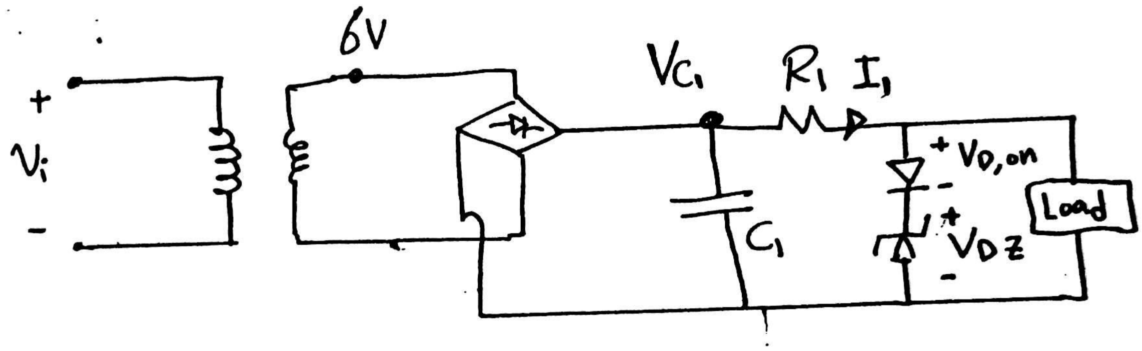
* Where V_R is the ripple voltage.

$$V_R = \left.\frac{I_{L\,max}}{2fC}\right|_{FWR} , \quad V_R = \left.\frac{I_{L\,max}}{fC}\right|_{HWR}$$

* We want to minimize V_R
  * We can't control (f ; I_L)
  * Practically we can't increase C
  * we minimize V_R by adding Voltage regulator circuit.

Final 2014 [24 Marks] !

* For the voltage shown in figure, $f_{in} = 50\ Hz$, $C_1 = 100\ \mu F$, $R_1 = 1000\ \Omega$, and the peak voltage produced by the transformer is equal to 6V. For simplicity neglect the load.



a] Assuming R_1 carries a relatively constant current, $V_{D,on} \approx 800mV$, $V_{DZ} = 2.7$, estimate ripple amplitude across C_1. [8 Marks]

Soln:

$f_{in} = 50\ Hz$, $R_1 = 1\ k\Omega$, $C_1 = 100\ \mu F$

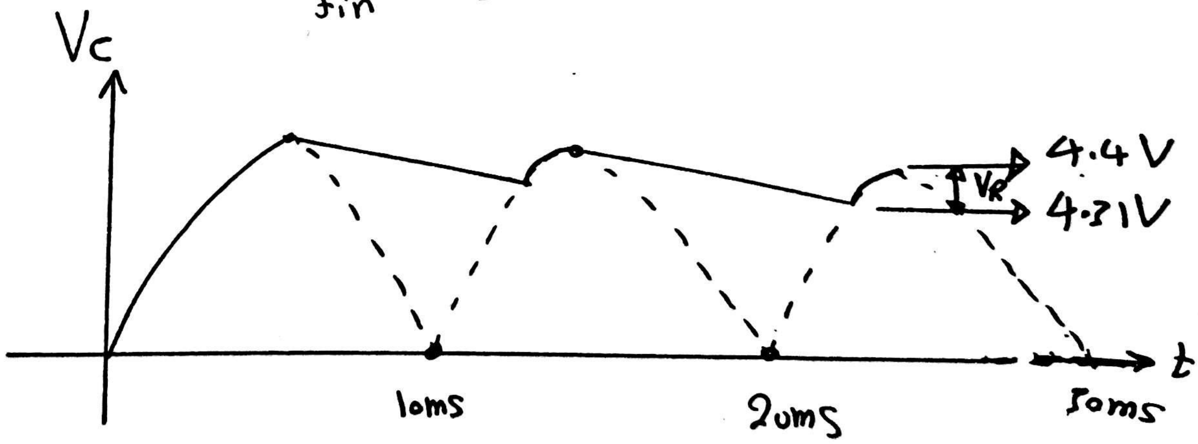
$$V_R = \frac{I_1}{2 C_1 f_i} = \frac{[V_{C_1 max} - (V_{D,on} + V_{DZ})] / R_1}{2 C_1 f_i}$$

$$V_R = \frac{[6 - 2*0.8 - (0.8+2.7)]/1}{2*100*10^{-6}*50}$$

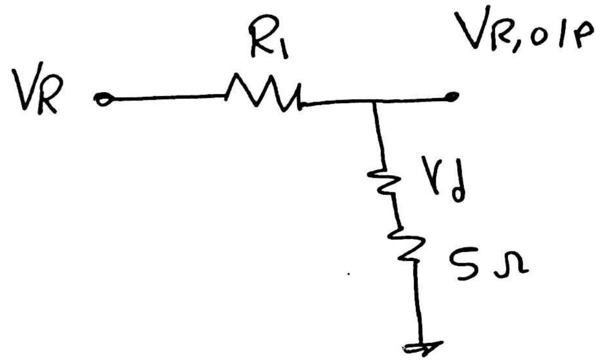
$V_R = 90\,mV$

b] Plot an approximate wave form for the Voltage drop across the Capcitor as a function of time. Indicate the maximum & min Values of the Voltage & the Period on your plot [8 marks]

Periodic time $= \frac{1}{f_{in}} = \frac{1}{50} = 20\,ms$



c] Using small-signal model of the diodes, determine the ripple amplitude across the Load. The Zener diode has a small-signal resistance of 5Ω. [8 Marks]

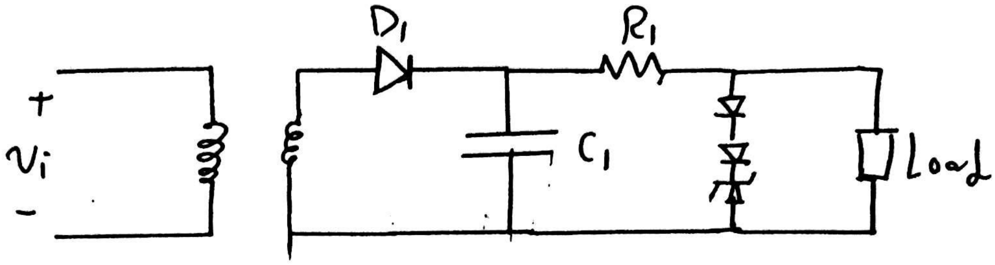


$$r_d = \frac{V_T}{I_D} = \frac{26}{(4.4-3.5)} = 28.88\,\Omega$$

$$V_{R,op} = V_R * \frac{r_d + 5}{R_1 + r_d + 5}$$

$$V_{R,op} = 90\,mV \;\frac{28.88+5}{28.88+5+1000} = 2.94\,mV$$

Final 2015: (24 marks)



$f_i = 50\,Hz$, $C_1 = 100\,\mu F$, $R_1 = 1000\,\Omega$, $V_{D,on} = 800\,mV$

Peak Voltage Produced by transformer $= 6\,V$.

For simplicity neglect Load

a) Determine Zener Voltage needed if the Load requires a maximum Voltage of 4.5 V.

b) assuming R_1 Carries Constant current, estimate ripple amplitude accross C_1

c) Plot approximate waveform for the voltage drop accross the capcitor as a function of time. Indicate the maximum & minimum values and the Period on your plot

d) Determine Zener diode small signal resistance needed for ripple amplitude accross the Load to be 10mV

e) what happens to the circuit If D_1 is reversed?

Soln

a)

$$V_{Load} = 2\,V_{D,on} + V_Z$$

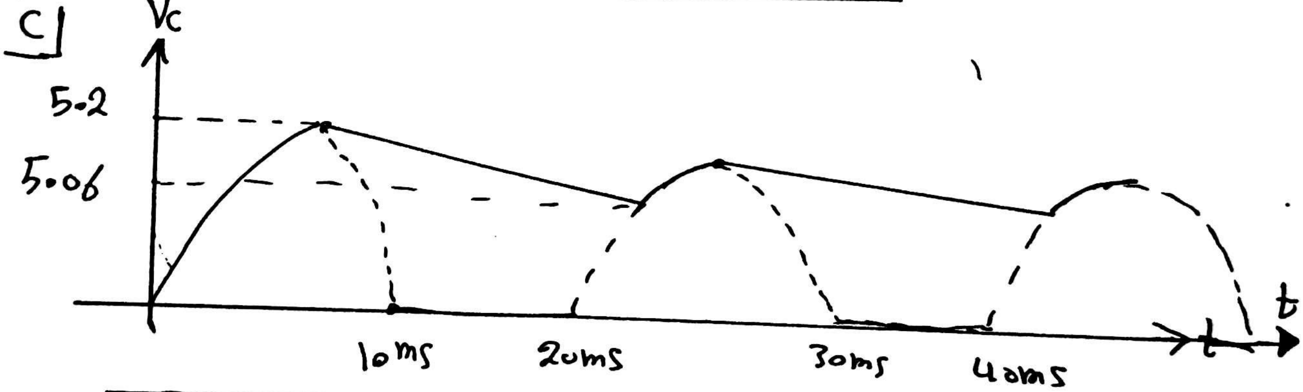
$$V_Z = V_{Load} - 2\,V_{D,on} = 4.5 - 2 * 0.8 = 2.9\ V$$

b)

$$V_R\Big|_{C_1} = \frac{I_L}{f_i\, C} = \frac{[(6-0.8)-(4.5)]/1k\Omega}{50 \cdot 100 * 10^{-6}}$$

$$V_R\Big|_{C_1} = 140\ mV$$

c)



d)

0.15 — 2000 — 0.01, r_d, r_d, r_{dz}

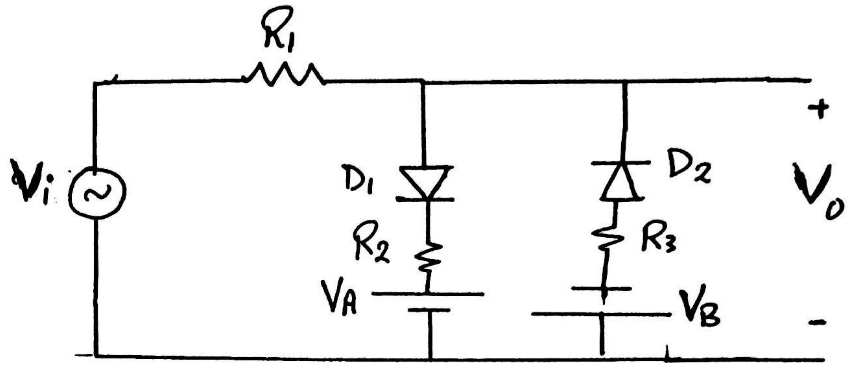
$$r_d = \frac{V_T}{I_D} = \frac{26}{0.7} \simeq 37$$

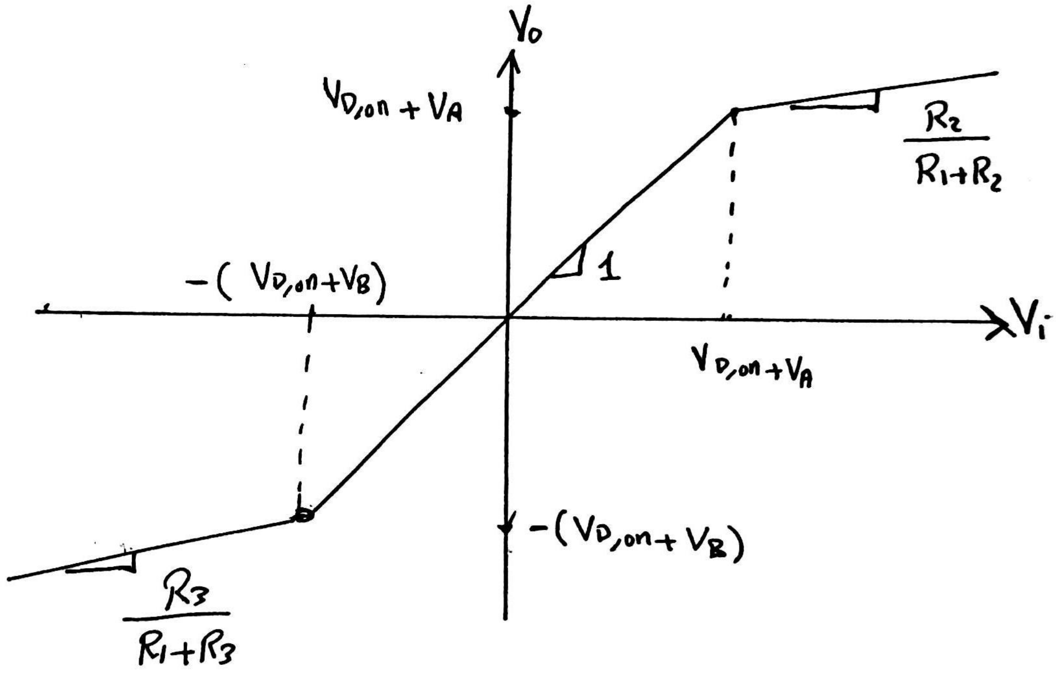
$$0.01 = 0.15\,\frac{2*37 + r_d}{2*37 + r_d + 1000}$$

$$r_{dz} = 2.57\ \Omega$$

e) $V_{C_1} = -V_e \rightarrow$ Diodes (off) $\rightarrow$ (No regulation occurs)

* General Clipping Circuit :



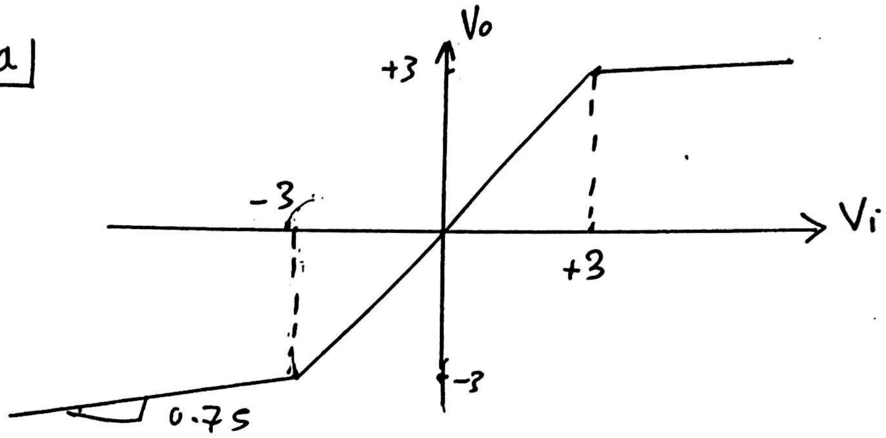


* أحفظ شكل الدائرة + رسمة (V_o/V_i)

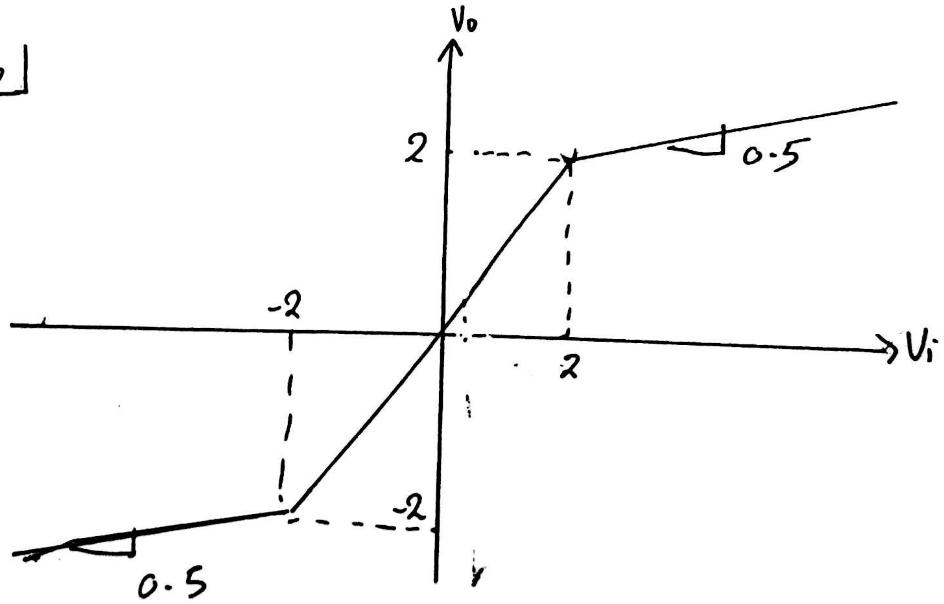
P6

We wish to design circuits that exhibits the input/output C/C's shown using ideal diodes, 1 kΩ resistors and other components.

a)



b)



Soln

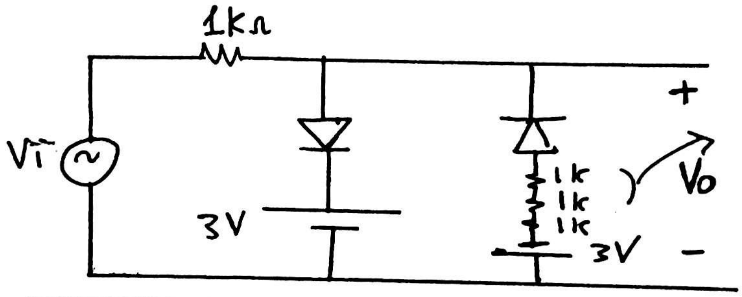
* Ideal diodes $\longrightarrow$ $V_{D,on} = \text{Zero}$

* Compare the given graphs with V_o/V_i of the Ideal Clipping circuit.

a) $V_A = 3V, \; V_B = 3V$

$$\frac{R_2}{R_1 + R_2} = 0 \longrightarrow R_2 = 0$$

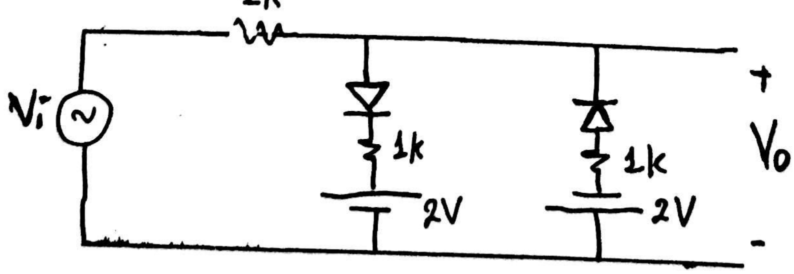
$$\frac{R_3}{R_1 + R_3} = \frac{3}{4} \longrightarrow R_3 = 3k\Omega, \; R_1 = 1k\Omega$$



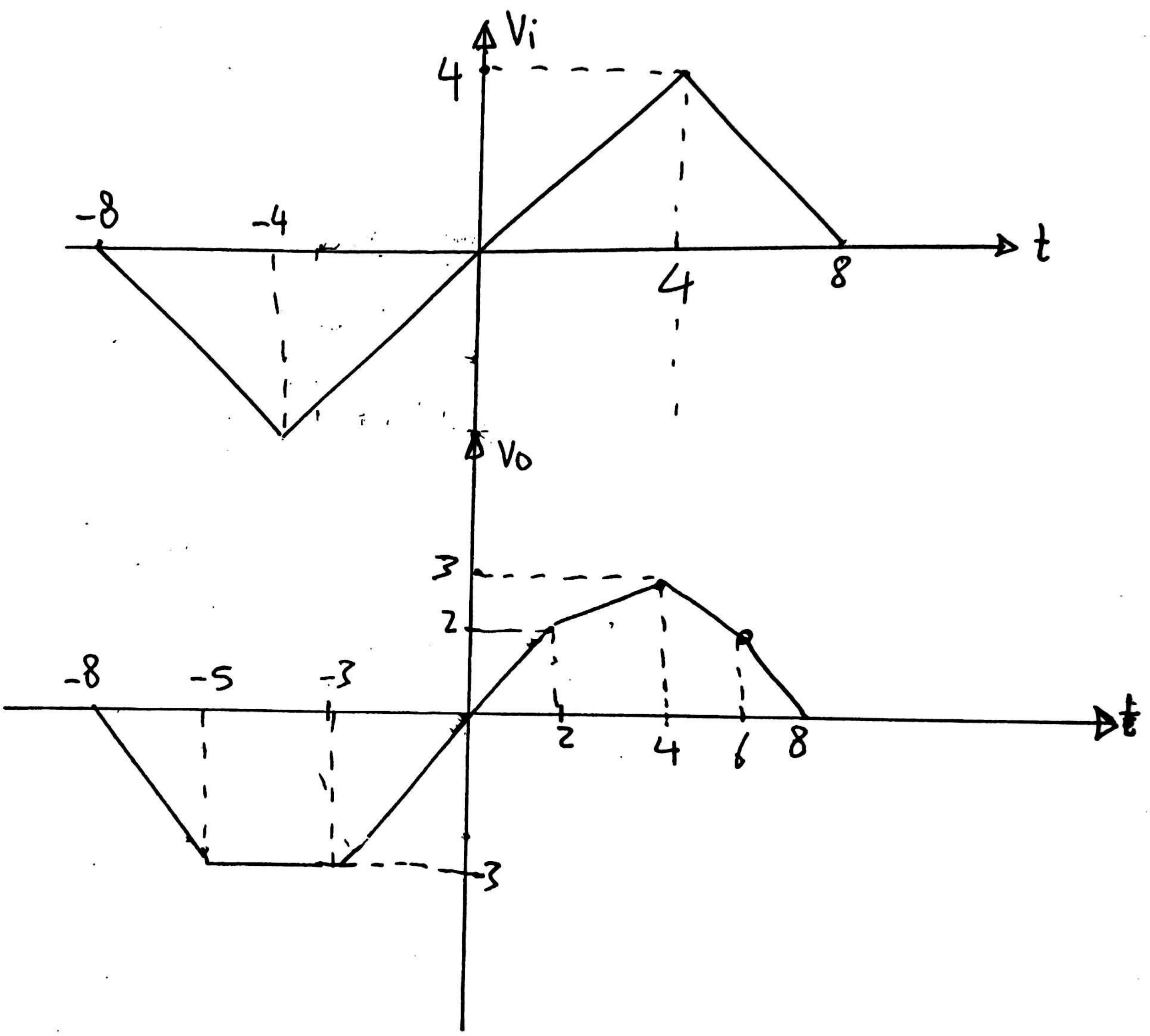
three series resistors each one = 1kΩ

b) $V_A = V_B = 2, \quad \frac{R_1}{R_1 + R_2} = \frac{1}{2} \longrightarrow R_1 = 1k\Omega, \; R_2 = 1k\Omega$

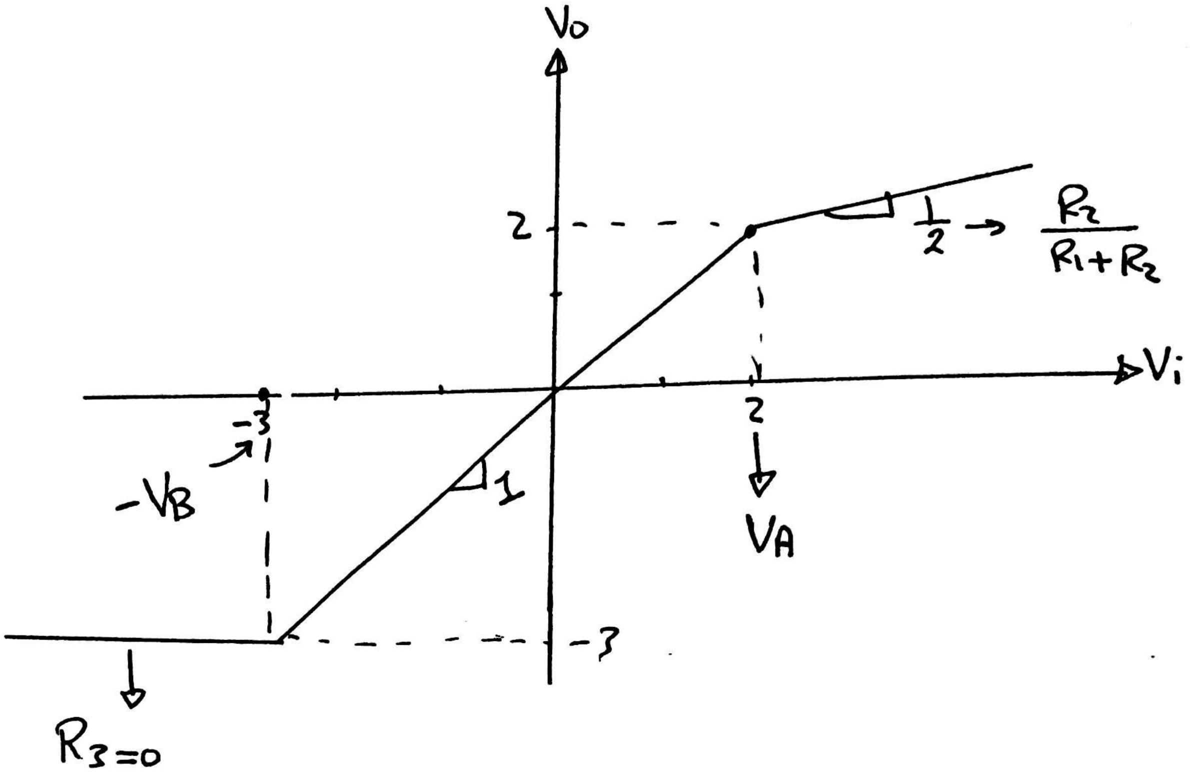
$$\frac{R_3}{R_1 + R_3} = \frac{1}{2} \longrightarrow R_1 = 1k\Omega, \; R_3 = 1k\Omega$$



* Design circuit using Ideal diodes & 1-kΩ resistors & other components such that:

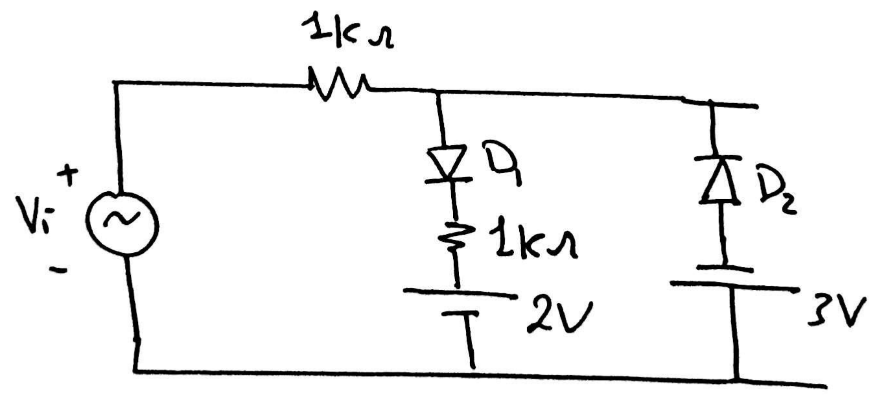


$$V_o = \begin{cases} -3 & V_i < -3 \\ V_i & -3 < V_i < 2 \\ \frac{1}{2} V_i + 1 & V_i > 2 \end{cases}$$



$V_A = 2V$, $V_B = 3V$, $R_3 = 0$, $\frac{R_2}{R_1+R_2} = \frac{1}{2}$

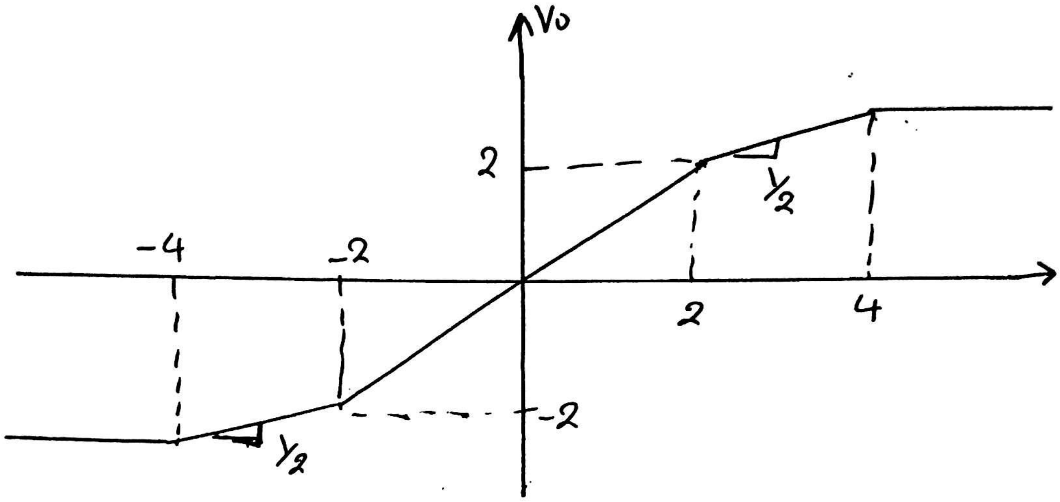
let $R_1 = 1k\Omega \longrightarrow R_2 = 1\ k\Omega$



*

P6

Construct a circuit that provides the following characteristic using ideal diodes and other components.



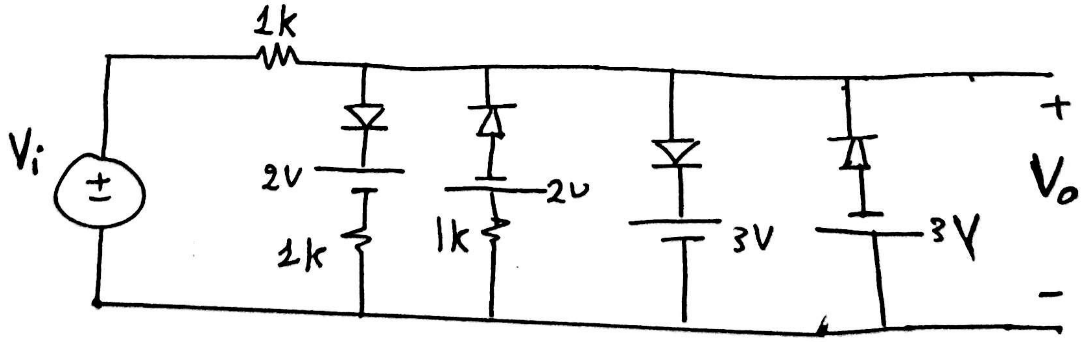
Soln

1) Design the circuit as $-4 < V_i < 4$

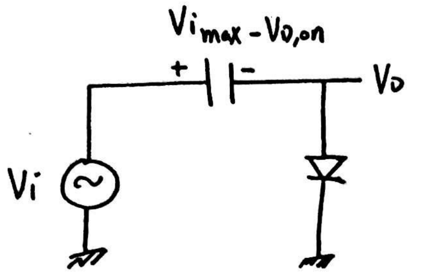
2) $V_i \geq 4 \Rightarrow V_o = 2 + (4-2) * \frac{1}{2} = 3V \rightarrow$ Battery

3) $V_i \leq -4 \Rightarrow V_o = -2 - (-4+2) * \frac{1}{2} = -3V \rightarrow$ Battery

$-4 < V_i < 4 \longrightarrow$ the circuit like previous P6 part b.

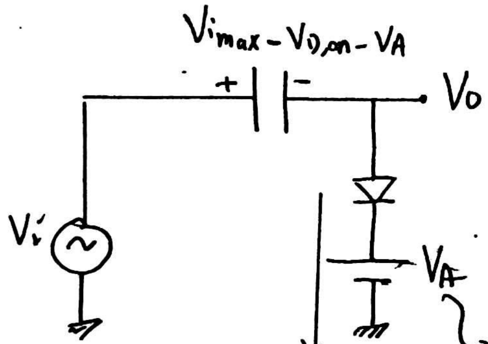


Clamping Circuits



Shift down

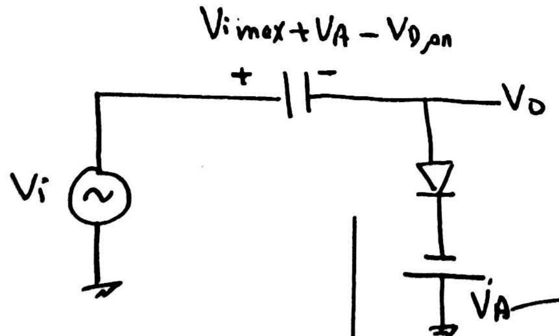
$$V_o = V_i - [V_{i\,max} - V_{D,on}]$$



$$V_o = V_i - [V_{i,\,max} - V_{D,on} - V_A]$$

reduce amaunt of shift

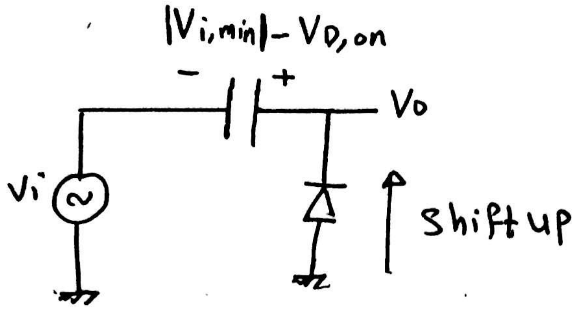
Shift down



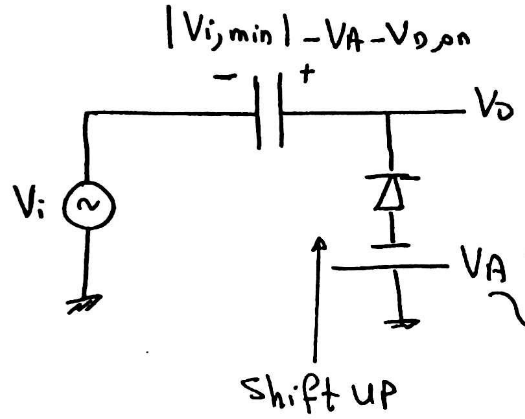
$$V_o = V_i - [V_{i\,max} + V_A - V_{D,on}]$$

Increase amaunt of shift

Shift down

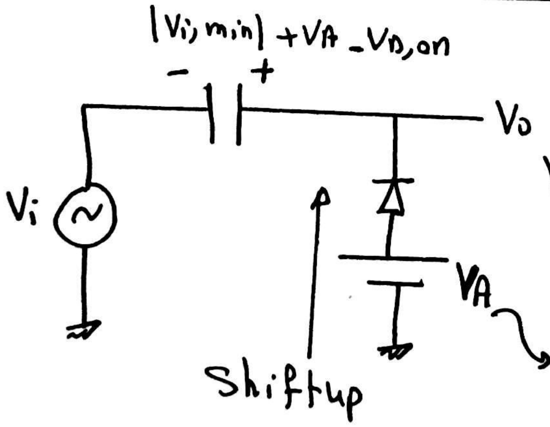


$$V_o = V_i + [\,|V_{i,min}| - V_{D,on}\,]$$



$V_o = V_i + |V_{i,min}| - V_A - V_{D,on}$

reduce shift

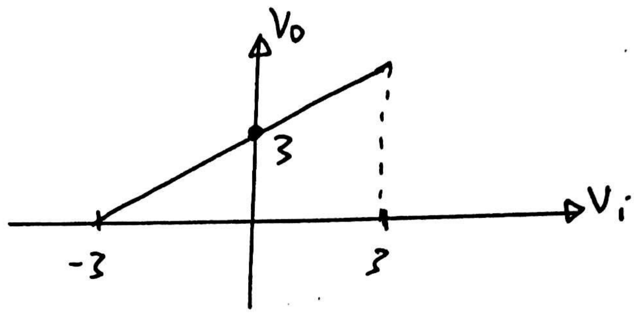


$V_o = V_i + |V_{i,min}| + V_A - V_{D,on}$

Increase shift

* Mid term 2015

We wish to design a circuit that exhibits the steady-state input/output c/c's shown. Using ideal diodes and other components, construct the circuit.



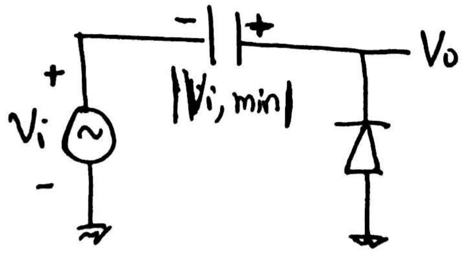
Soln

$$-3 \le V_i \le 3$$

$V_{i,min}$ $\swarrow$ $\searrow$ $V_{i,max}$

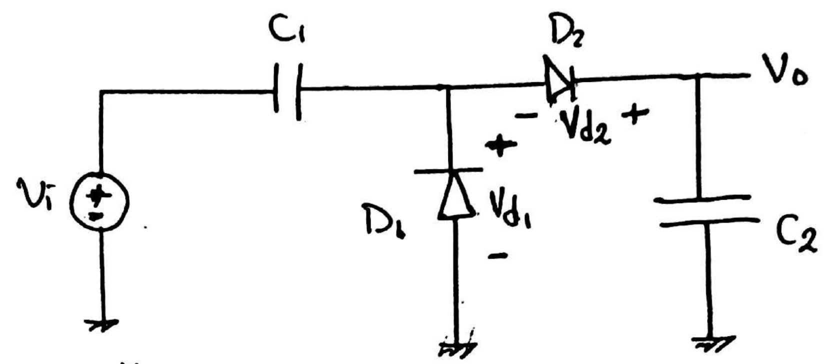
$\longrightarrow$ $V_o = V_i + 3 = V_i + |V_{i,min}|$

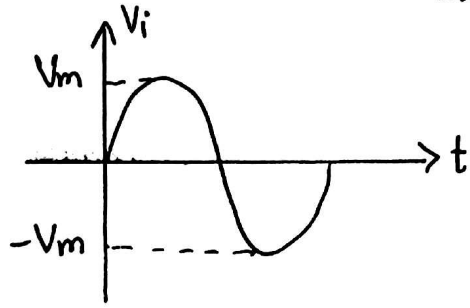
Shift up clamping circuit.



Voltage doubler:

* Zaker malzma (18) from page(23) → page(26)

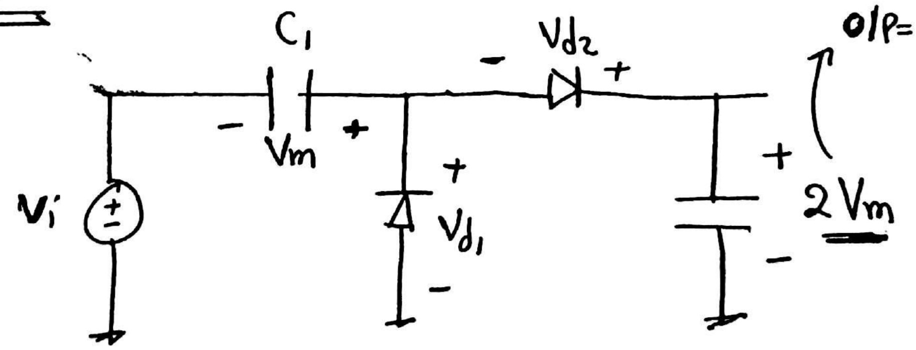




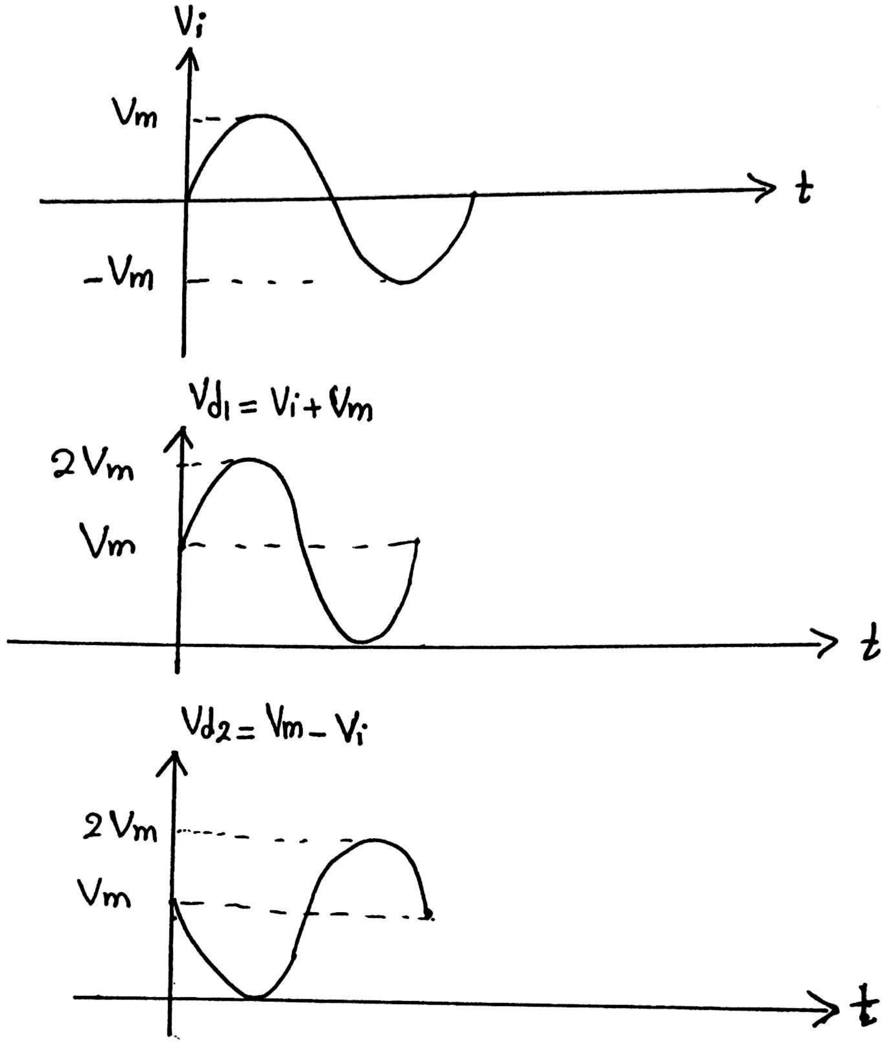
, Draw V_{d1}, V_{d2} .

Soln

note
O/P = double $(V_i)_{max}$

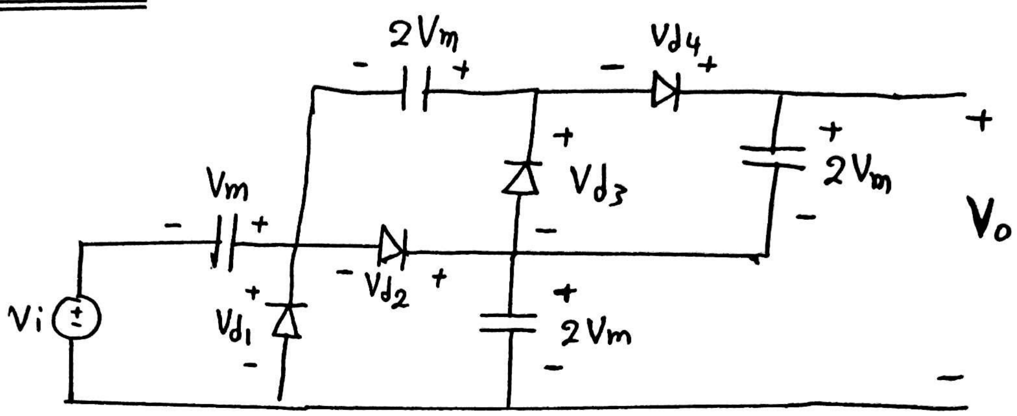


$\boxed{V_{d1} = V_i + V_m}$, $-V_{d1} - V_{d2} + 2V_m = 0 \Rightarrow \boxed{V_{d2} = V_m - V_i}$



P Generalize the Concept of Voltage doubler Circuit to produce $V_o = 4V_m$, $V_m = (V_i)_{max}$

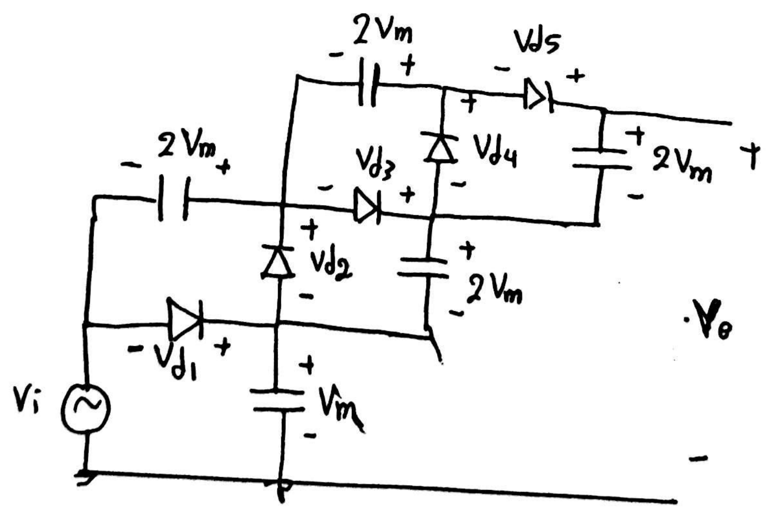
Soln



$V_{d1} = V_i + V_m$, $V_{d2} = V_m - V_i$, $V_{d3} = V_i + V_m$

$V_o = 2V_m + 2V_m = 4V_m.$

Pb Using voltage daubler circuit, Design Circuit such that $V_o = 5V_m$, $V_m = (V_i)_{max}$



$V_{d1} = V_m - V_i$

$V_{d2} = V_i + V_m$

$V_{d3} = V_m - V_i$

$V_{d4} = V_i + V_m$

$V_o = 2V_m + 2V_m + V_m$

$V_o = 5V_m$

#

* Types of diodes :

- Types of diodes
  - Zener diode
  - Varactor diode
  - Schottky diode
  - optical diodes
    - Photo diode
    - Light emitting diode (LED)
    - Solar cell
    - Laser diode (LD)

* Zener diode :

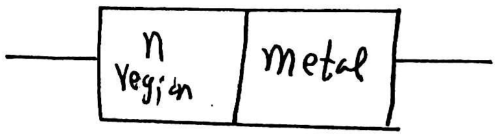
* FWD direction ⟶ like normal diode
* RVS direction ⟶ Battery
* Zener diode is heavily doped to avoid Avalanch break down.

* Varactor!

* Used as Capcitor in the reverse bias.
* No useful purpose in forward bias.

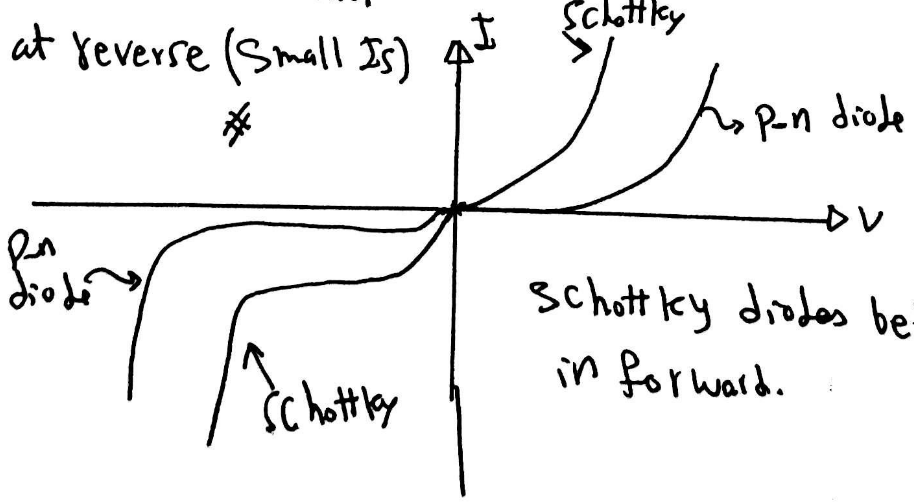
*Schottky diode!

* fast switching Speed [Pico seconds].
* Useful for high frequency & digital applications
* Current only due to maJority electrons



Schottky diode

P-n diode is better at reverse (Small I_s) *



Schottky diodes better in forward.

* Light-Emitting Diodes: LED

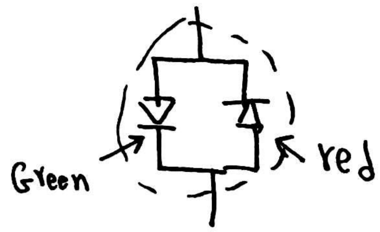
* LED is a diode that gives visible light when forward biased.

* When electron makes recombination with hole, then, release energy in the form of light [photon].

* Colors result from choise of substrate material.

Multi color LED:

* Emits one color when forward biased & another color when reverse biased.



* If we make fast switching between FWD/RVS LED will produce third color [red/green] → yellow color

Application → Seven segment display

* Photo diode :

* A Photo-diode is a reverse biase pn Junction.

* When Junction is exposed to light, then, electrons & holes will be generated Leads to increasing of reverse biase current

Application: digital camera & Photo detector.

* Solar cell :

* Solar cell can be considered as a large area Photo diode

* Solar cell used to generate electric solar Power.

* Solar Cell converts solar energy to direct current [Dc Current]

* Laser diode

* make generation to Laser by stimulated emission.

* have three pins to connect Photo diode needed for controlling Laser saura

MCQ questions:

Part (1): 10 questions

1. Read malzma (11) without solving problems
2. Read Type of diodes
3. Read malzma (13) & malzma (18) without solving problems.

MCQ Final 2014 (Sameh only)

1. The energy gap is highest for

a) Conductors
b) semiconductors
c) Insulators
d) They are all equall

---

2. The Fermi level is close to the conduction band edge in

a) n-type
b) p-type
c) intrinsic
e) Non of the above

---

3. Drift current denisty is directy proportional to

a) Concentration gradient
b) width of semiconductor
c) Electric field
d) All of the above

---

4. Diffusion currents flows

a) From high concentration to low concentration
b) In the electric field direction
c) From low concentration to high concentration
d) Depends on the carrier type.

5. ⟶ (ما تعترها ش)

6. the Capcitonce of reverse baised diode:

a) In Creases with reverse bias Voltage
b) Is not Voltage dependent
c) decreases with reverse bias Voltage
d) increases with built in Potential.

---

7. The Constant Voltage model of the diode neglects

a) Reverse break down
b) Reverse saturation current
c) Diode current dependency on diode Voltage
d) All of the above

---

8. To get DC Voltage from an AC signal, we use

a) Full wave rectifier
b) A smoothing capcitor
c) A voltage regulator
d) All of the above

---

9. To Prevent the Voltage from passing certain value we use:

a) A clipping circuit
b. A Clamping circuit
c) voltage doubler
d) A half-wave rectifier

10. Assuming Ideal diodes, the autput of the Voltage daubler reaches $2V_P$

a) Instantaneausly
b) Steady state
c) After one cycle
d) Never

Note

When two PN Junctions put in Parallel, then, they are effectively one PN Junction with twice the Cross-Section Area, and hence twice the Current.

Answers : Final 2014 :

1. c

2. a

3. c

4. d

6. c

7. d

8. d

9. a

10. b

MCQ Final 2015 (Sameh only) :

1. The Lattice structure that has highest atomic density is:

a. Simple cubic (SC)
b. Body-Centered Cubic (BCC)
c. Face-Centered cubic (FCC)
d. Diamond

---

2. Electrons conduct electricity when they are

a. Valence band
b. Conduction band
c. energy gap
d. All of the above

---

3. A P-type semiconductor is obtained when silicon is doped by

a. Boron
b. Phosphorus
c. Arsenic
d. Sodium

---

4. the resistivity of a semiconductor

a. Increases with Carrier Concentration
b. Increase with length
c. Decrease with mobility
d. All of the above

5. In a forword-bias PN Junction:

a) Majority Carriers mainly drift

b) Majority Carriers mainly diffuse

c) the depletion region expands

d) No current flows

---

6. The Ideal diode model of the diode neglects:

a) Reverse break dawn

b) Reverse saturation current

c) Diode current dependency on diode voltage

d) All of the above

7- To increase the input Voltage Level, we use

a) A Full-wave rectifier

b) Voltage daubler

c) A Voltage regulator

d) All of the above

8- The ripples in a full-wave rectifier

a) Increase with Load current

b) Increase with Load capacitance

c) Increase with input frequency

d) All of the above

9. The following diodes are used in forward-bias mode:

a) Light emitting diodes (LEDS) b) Laser diodes (LDS)

c) schottky diodes d) All of the above

10. The color of a LED is only determined by the semiconductor energy gap in

a) white LEDS b) Red LEDS

C) Multi-Color LEDS d) Non of the above

Answers: Final 2015

1. d

note: * Simple cubic (SC) → Atoms/Cell = 1

* Body-Centered cube (BCC) → Atoms/Cell = 2
* Face-Centered cube (FCC) → Atoms/Cell = 4
* Diamond → Atoms/Cell = 8

note: silicon is a single crystal Periodic across the whole Volume.

* SC → only Polonium
* BCC → Sodium
* FCC → Copper
* Diamond → Silicon

---

2. b

3. a → note → P-type (Boron, Aluminum, Gallium)
→ n-type (phosphorous, arsenic, antimony)

4. c

5. a

note: FWD bias → majority moves by drift
→ minority moves by diffusion

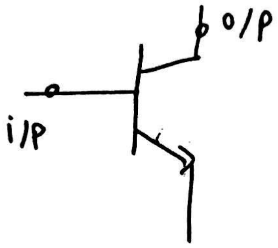
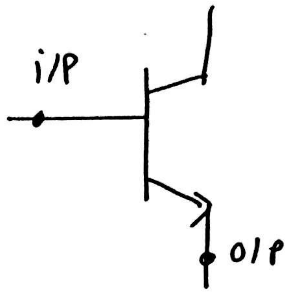
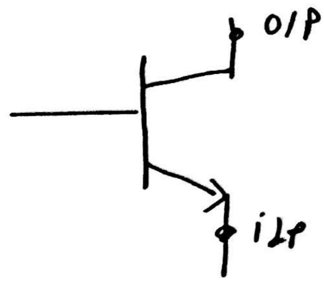
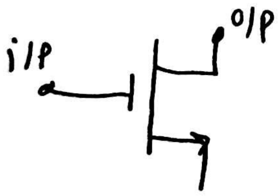
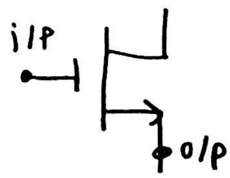
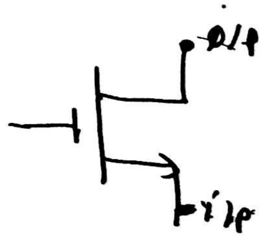
6. d

7. b

8. a , $V_R\Big|_{FWR} = \dfrac{I_L}{2fC}$

9. d

10. b

<table>
<tr><th>CE</th><th>CC</th><th>CB</th></tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>$A_v = -ve$
$A_v \uparrow\uparrow$
$R_i \uparrow\uparrow$
$R_o \uparrow$, $A_i = -ve$, $\uparrow\uparrow$</td>
<td>$A_v = +ve$
$A_v \simeq 1$
$R_i \uparrow\uparrow$
$R_o \downarrow$, $A_i = +ve$, $\uparrow\uparrow$</td>
<td>$A_v = +ve$
$A_v \uparrow\uparrow$
$R_i \downarrow$
$R_o \uparrow\uparrow$, $A_i \simeq 1$</td>
</tr>
<tr><th>CS</th><th>CD</th><th>CG</th></tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>$A_v = -ve$
$A_v \uparrow\uparrow$
$R_i \uparrow\uparrow$
$R_o \uparrow$
$A_i = -ve$, $\uparrow\uparrow$</td>
<td>$A_v = +ve$
$A_v \simeq 1$
$R_i \uparrow\uparrow$
$R_o \downarrow$
$A_i \uparrow\uparrow$</td>
<td>$A_v = +ve$
$A_v \uparrow\uparrow$
$R_i \downarrow$
$R_o \uparrow$
$A_i \simeq 1$</td>
</tr>
</table>

Comparison between BJT, JFET, MOSFET :

	BJT	JFET	MOSFET
Normally	off	ON	off
current mechanism	Diffusion	Drift	Drift
Amplifier	Active	Saturation	Saturation
Condition of Saturation / Triode	Saturation $V_{CE} = 0.3$	Triode $V_{DS} < V_{GS} - V_P$	Triode $V_{DS} < V_{GS} - V_t$
Size	Large	Small	Small
I/V C/C's	exponential	Quadratic	Quadratic

MCQ questions Part (9) : 10 questions :

1. Read Physics in → Final Revision Part 1
2. Read malzma (9) → " " Part 2
3. the Previous relations are very impt.